Magnetorheological properties of soft ferrogels

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The macroscopic properties of magnetoactive gels and elastomers, their dependence on external magnetic field are determined by the disposition of particles in the host polymer, structural transformations occurring under the influence of the field, and large-scale deformations suffered by the material. The size of the particles together with their shapes and concentration, the overall formula of the composite including the nature of the host polymer are also important factors lying behind the specifics of the field-sensitivity.

Multiple experiments performed on MRE have resulted in a significant collection of research data pointing to a strong relationship between the rheological characteristics of the material, their internal structure and magnetic field; the strength of the MR-effect demonstrated by MRE has been in the focus of attention of researchers for a while. Observations indicated that samples polymerized under the influence of a magnetic field exhibited much stronger MR effect than the isotropic composites did.

Despite the fact, that investigations dedicated to the MR-effect are numerous and the overall data collection is huge, the information available does not suffice for making the complete picture of the physical nature of this effect. In part, the role of the internal transformations in the observed magnetomechanical phenomena is not fully understood. In this work we present results of experimental and theoretical study of effect of the particles aggregation, on the macroscopic magnetorheological effects in soft the composites, cured without magnetic field.

Experiments demonstrated that the MR effects in the system under study were significantly more than those, expected based on standard models of mechanical properties of composite materials with chaotically disposed spherical particles. In order to explain the observed effects, we used the concept of the particles chaining under the applied field. The mathematical model includes equations of the particles and chains displacement under the forces of magnetic attraction between them and elastic resistance of the host medium as well. Solution of these equations allowed us to determine distribution of the chains over number of particles. Combining this function with equations of the chain deformation, provoked by the global deformation of the sample, we have estimated the macroscopic mechanic stress in the composite, determined dependences of the material elastic modulus on the applied field, particles concentration and other parameters of the system.

The results of the mathematical model are in agreement with the experimental data's.